deflected edge; external border convex, much raised and strongly undulato-plicate, the ridges being largest in front, and gradually diminishing towards the external and posterior portion of the tooth; the plicæ are produced by a thickening of the substance of the ridges and a scooping-out of the intervening hollows, so that the under side of the tooth remains even; under surface coarsely osseous; upper surface polished, with small obscure undulations and minutely porous.

This genus is closely allied to *Ceratodus* and *Ctenodus*, but differs in the grinding surface being concave, the tooth resembling the inside of a plicated oyster. The internal microscopic structure was developed for me by the kindness and skilful manipulation of my friend Mr. Anthony of Caius College, Cambridge; it was very complex and peculiar, but the prepared fragment has unfortunately been mislaid, so that I am unable now fully to describe it. I only know one species, the following.

Conchodus ostreaformis (M'Coy).

About $1\frac{1}{2}$ inch long, 1 inch wide, and $1\frac{1}{2}$ line thick, the grinding surface deeply concave, the surface of attachment equally convex; the external semicircular margin gives origin to six or seven coarse, rugged, converging ridges, the most anterior about 7 lines long and slightly inclined to the straight inner margin, the most posterior is about 2 lines long and at right angles with the inner margin; the ridges are separated by deep, wide hollows.

Found along with *Dendrodus latus* (Ow.), *Holop. giganteus* (Ag.), and *Hol. princeps* (M'Coy), in the old red conglomerate of Scat Craig.

(*Col.* University of Cambridge.)

XXXIII.—*On an apparently undescribed state of the* Palmelleæ; *with a few observations on Gemmation in the lower tribes of Plants.* By G. H. K. Thwaites, Lecturer on Botany and Vegetable Physiology in the Bristol Medical School.

[With a Plate.]

The importance—the necessity, it may be said,—of an acquaintance with the lower forms of the vegetable kingdom, in order to afford a clear insight into the real character of the phænomena of growth and reproduction in the higher tribes of plants, is now pretty generally felt and acknowledged by physiologists. From the study of the simpler organisms only can we hope to obtain a correct understanding of the changes which take place

during the very early or embryonic condition of the more complicated structures; whilst a comparison with these latter may serve best to show us the true nature of certain phænomena connected with the development of those simpler organisms.

The *Palmelleæ* have generally been looked upon by botanists as occupying the lowest place in the vegetable kingdom, and on this account any new fact connected with their mode of growth is of peculiar interest. These simple plants generally appear as gelatinous masses of an irregular form, and, viewed under the microscope, as consisting of a number of similar cells imbedded in a gelatine; these cells having no essential organic connexion with each other, but being merely held together by the gelatine with which each is surrounded. In the opinion of some physiologists, each of the cells, on account of its possessing an independent vitality and seeming capable of performing all the functions necessary for the growth and reproduction of the species, is to be regarded as representing an individual plant. If, however, we adopt this view of the matter, we must suppose every process of fissiparous division taking place in the cells as a true reproduction of the species, which surely cannot be the case, as will be endeavoured to be shown.

In the gelatinous masses of the *Palmelleæ* numerous branched filaments are found to occur; these have been figured by Professor Kützing in his 'Tabulæ Phycologicæ*,' as pointed out to the writer by Mr. Berkeley; and they have been described by Mr. Hassall in his 'British Freshwater Algæ†,' but neither of these two authors seems to have understood the real character of these filaments. Mr. Hassall remarks that they "may either be parasitic growth, or else form part of the organization of the frond; and in the latter case they may be presumed to be connected with respiration." To the researches of Mr. C. E. Broome, however, is due the discovery of their true nature. When examining in January last some portions of a mass of *Palmella botryoides*, Greville, this excellent observer found that the cells, in an early stage of the plant, are attached singly to the extremities of branched tubular filaments, which are filled with endochrome, and are attached to and radiate from a central large cell of irregular shape (Pl. X. fig. 1); that the cells subsequently become detached, and each is then seen situated at the end of a mucous prolongation (Pl. X. fig. 2) such as is described and figured by Mr. Hassall‡ in some species of this natural family.

The writer has been enabled to confirm his friend Mr. Broome's interesting discovery by detecting the attachment of the cells to

* Tab. Phycologicæ, tab. 19. iv., 21. v., 24. i., 25. i. & v., 26. i. & ii.
† Brit. Freshw. Algæ, p. 318. ‡ Ibid. p. 323, tab. 80.

branched filaments in the *Coccochloris rubescens*, Brébisson, as well as in the above-named *Palmella*. This is rendered more interesting from the circumstance of the *Cocc. rubescens* being one of the species in which M. de Brébisson, as stated by Mr. Ralfs*, has observed conjugation taking place, a process which will probably be found to be general amongst the *Palmelleæ*, and to be the true mode of reproduction in all the species.

Upon comparing the filamentous condition of the *Palmella*, as above described, with one of the lower Fungi—with a *Botrytis*, for example,—we might at first feel disposed to conclude that in one as in the other the cells terminating the filaments are to be deemed the true reproductive organs, since in both species the cells become detached and give origin to structures having no organic connexion with the original ones. Upon reflection, however, we shall find that very different is the relation in which the detached cells of the *Palmella* and those of the *Botrytis* stand to the filaments from which they have respectively become separated. In the *Botrytis* the plant has reached its perfect development, and the terminal deciduous cells are evidently the reproductive spores; but the *Palmella* is in an immature state, and the branched filaments may more correctly be compared with the mycelium of the higher Fungi, or with the early confervoid filaments of the Mosses. In the *Palmella* the separation of the cells from the filaments may be considered as really a subdivision of the plant—a gemmation—a multiplication of the individual rather than a reproduction of the species; and the subsequent fissiparous division of these detached cells into other equally independent organisms as a continuation of the process of gemmation; the individual plant itself being the aggregate of all the cells so produced previously to true reproduction taking place.

It is very interesting and important to observe the extent to which the process of gemmation takes place in the lower tribes of plants, and this is especially evident in the Mosses. From the negative evidence adduced by Bruch and Schimper, there can be little doubt that the theca of the moss, with its contents, is the product of the fertilization of the *pistillidium*. It would follow then that the theca and the entire mass of sporules contained within it are equivalent to one embryo of the flowering plant, and that consequently the subdivision of this reproductive matter into a number of sporules is equivalent to the multiplication of the individual plant by a process of gemmation;—that in fact it may be termed an intra-thecal or sporangial gemmation. Again, in tracing the development of one of these sporules after its escape from the moss-theca, we find that it gives origin to a con-

* Ralfs's 'British Desmidieæ,' p. 37.

fervoid structure*, and that subsequently upon this latter are produced a number of gemmæ, each of which commences an independent growth and quickly puts on the perfect moss-structure. Finally, after the moss-phyton has become fully developed we still perceive the process of gemmation going on,—either by the production of gemmæ upon the stem, as in *Aulacomnion androgynum*, Schwaegr., or upon the confervoid roots.

In the Mosses then we find the *species reproduced* by a process of impregnation;—at least such seems most probable. And we see the *individual plant multiplied*—1st, by a subdivision of the embryonic matter into a number of sporules (*sporangial gemmation*); 2ndly, by the production of gemmæ upon the confervoid filaments previously to the moss putting on its perfect form (*mycelial gemmation*); and 3rdly, by gemmæ being developed upon the moss when in its mature state (*gemmation proper*).

There can be little doubt that these same phænomena obtain in many if not in most of the lower plants; and there is every reason to believe that what is frequently described as a second form of fructification amongst the Algæ—for instance, the *tetraspores* of the *Florideæ*, the *opseospermata* of the *Chætophoreæ*, and the terminal "*spore*†" of *Vaucheria*—are in reality true gemmæ: and although it may be some time before we shall be able to determine with certainty, in some of these lower forms, the true character of what is usually termed *fruit*, yet we may at once get red of the anomaly of one plant being said to produce two kinds of true spores; and we shall doubtless in course of time arrive at the discovery of some general laws to guide us in the right discrimination of these structures.

It is a fact well known to botanists that some species of Mosses rarely if ever occur with true fructification in certain localities, and the same may be said of other cryptogamous plants. As instances of this kind amongst Mosses may be cited *Encalypta streptocarpa*, Hedwig, and *Trichostomum flexicaule*, B. & S.; and *Parmelia physodes*, Ach., and *Placodium canescens*, DeCand., amongst Lichens. These then and many others owe their multiplication and dispersion principally to the agency of gemmæ. If we

* Some cryptogamous plants, in this stage of their growth, exhibit so close a resemblance to the mature state of other plants still lower in the scale of vegetation, that without due care in watching the progress of their development, they may easily be set down as distinct species.

† The circumstance of such an organism being for a short period in its earliest condition provided with mobile cilia seems scarcely to furnish an argument in favour of its possessing a higher character of organization than it does subsequently when these organs have disappeared. There is little doubt that the motion of the cilia is due to the changes taking place within the cell, and the cilia themselves are probably a mere modification of ordinary cell-membrane.

duly consider this fact, how much does it exalt the lower tribes of plants in our estimation! since we may contemplate an individual plant of them not as the single phyton—not as the single frond—not as the single cell—but as the aggregate of, it may be many thousands of, these;—view it occupying as much space and exercising as great an influence in the œconomy of nature as the largest forest tree; and as rivalling this even in longevity. It must be remembered that in the tree the manifestation of vitality is entirely in the recently formed leaf-buds in progress of development.

Under the influence of preconceived opinions it is difficult at first to take the view of the subject now offered, and it seems easier to view each leaf-bud of the tree, rather than the tree itself, as a distinct individual plant, comparing the former with the phyton of the lower plant. We must, however, go further than this:—the gemmæ of the *Palmella* are *analogous*, it is true, to the *leaf-buds* of the higher plant, but they are *homologous*, which is of higher importance with reference to this question, to the *individual cells* of the higher plant. To be consistent, therefore, we should be driven to the necessity of regarding the higher plant as made up of as many individual plants as there may be cells in its tissues. Now there can surely be few physiologists who would be disposed to adopt such an opinion; notwithstanding it cannot be denied that each of such cells possesses a greater or less independent vitality of its own. The application too of such a doctrine to the animal kingdom would appear to be impossible.

To some it may appear of little importance whether any particular vegetable organism is to be regarded as a complete individual plant, or as merely a part or subdivision of such,—whether it is the entire product of a true impregnation or a portion of it; but to the physiologist the general question is one of very great interest, since the solution of it enables him to compare correctly the higher with the lower forms of vegetation, and to understand what may previously have appeared anomalies in the vegetable kingdom.

EXPLANATION OF PLATE X.

Fig. 1. Portion of mass of *Palmella botryoides*, Grev., in an early stage of development, showing the cells attached to the tubular filaments.

— 2. Cells of the same species, when in a more advanced stage of growth, each seated at the end of a mucous prolongation.

All highly magnified.